Predicting the Distribution and Properties of Buried Submarine Topography on Continental Shelves

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LONG-TERM GOALS

The long-term goal of the Geoclutter modeling project is to predict the distribution and properties of buried channels that may be responsible for geoclutter on continental margins of interest.

OBJECTIVES

The overall objectives of our project are

1) to determine the characteristics of channel features that can form when the present continental shelf is subject to sea-level variations and

2) to determine whether these features would be buried when sea-level returned to its present position and, if so, how deeply. During FY05, we have been working on a no-cost extension to allow a graduate student to complete her study of incision rates on the coastal plain, which we are using as an analog to the continental shelf during periods of low sea-level stand..

APPROACH

Our approach is to develop numerical simulation models of landscape evolution to investigate the development of topography on the shelf during sea-level low stands and the burial of that topography during high sea-level conditions. Our model is based on Alan Howard's drainage basin evolution model, DELIM. Alan Howard and Sergio Fagherazzi (at FSU) have adapted, tested, and applied the landscape evolution model to coastal plain settings and exposed continental shelves. Sergio Fagherazzi has developed and implemented coastal modules and Patricia Wiberg has developed shelf sediment transport modules for the land/sea-scape evolution model.

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WORK COMPLETED

The drainage basin evolution model, DELIM, has been applied to high resolution DEMs of the coastal plain site to model erosion of coastal plain sediments and to determine channel incision rates on the coastal plain over the last 3.5 ma.

RESULTS

Erosion of continental shelves exposed during sea-level lowstands should progress rapidly in the absence of vegetation, as documented by rapid development of badlands in Coastal Plain Sediments (Howard and Kerby, 1983) and simulation modeling (Fagherazzi et al., 2004). However, natural vegetated landscapes in such sediments have persisted for several million years with moderate dissection. As continental shelves become exposed by lowering sea level, vegetation should be rapidly established, which should have the effect of reducing the frequency (drainage density) of streams and would protect hillslopes from rapid erosion. We have modeled landform evolution on a Coastal Plain landscape near Colonial Beach, Virginia in an area mapped in detail by our collaborator, Wayne Newell of the USGS (Figure 1). This area is characterized by multiple dissected terraces ranging in age from about 3.5 ma to 0.12 ma. In our modeling we utilize a relative land-sea level curve based upon heights and approximate ages of the terraces, the late Quaternary eustatic sea level curve, depth of Quaternary incision of the Potomac River, and a long $\delta^{18}O$ deep sea record (Figure 2). Our simulations start from the level of the 3.5 ma terrace at about +57 m, and the local base level follows the relative sea level curve. At 0.62 and 0.12 ma bp erosion of wave cut terraces is simulated by planing a portion of the simulation domain to the relative sea level at that time. A typical final simulation state is shown in Figure 3. We are quantitatively comparing morphometric properties of the simulated landscapes created with various assumed model parameters with the natural landscape. In order to preserve higher hill summits near the level of the 3.5 ma terrace, we must assume a vegetation-induced critical shear stress of about 200 N/m^2 for contributing areas less than 3000 m^2, diminishing to near zero by 60,000 m^2. We also find that the total dissection is a sensitive function of the assumed lowest water elevations occurring within the Potomac River relative to those in the open ocean. Results of these simulations will be published in the near future.

IMPACT/APPLICATION

The models we are developing provide quantitative information about channel depth, geometry, and fill for use in algorithms to reduce acoustic clutter associated with buried channels on the continental shelf.

RELATED PROJECTS

This work is bring carried out in collaboration with Sergio Fagherazzi of Florida State University. The models that we are developing in this project are likely to become part of the Community Surface Dynamics Modeling System (CSDMS) once it is established.

REFERENCES

Fagherazzi, S., A.D. Howard, and P.L. Wiberg, Modeling fluvial erosion and depositon on continental shelves during sea level cycles, *Journal of Geophysical Research*, *109*, F03010, doi:10.1029/2003JF000091, 2004.

Howard, A.D., and G. Kerby, Channel changes in badlands, *Geological Society of America Bulletin*, *94* (6), 739-752, 1983.

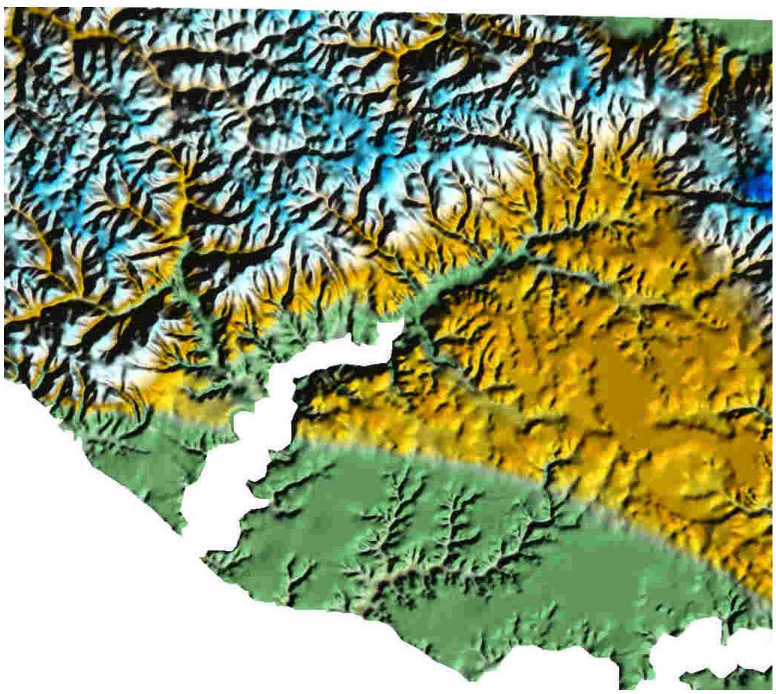

Figure 1. A portion of the Colonial Beach South Quadrangle, Virginia. Image width about 10 km. North is down. Uncolored areas are the Potomac River and marginal estuaries.

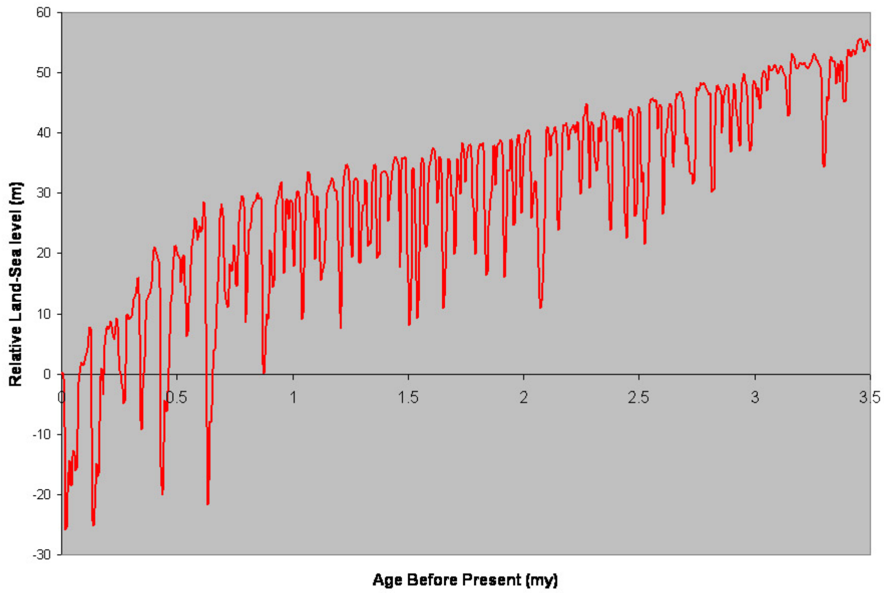

Figure 2. Assumed variation of relative sea level in the Colonial Beach area of Virginia for the past 3.5 ma showing an overall trend of lowering sealevel with superimposed hgher-frequency sea-level oscillations.

Figure 3. Simulated Coastal Plain landscape. The lower boundary is the controlling base level, assumed to be the bank of the Potomac River. The simulated domain is about 5.1 by 5.1 km.